Movable Thomson Scattering Based on Optical Fiber

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We do a design-study on a compact movable Thomson scattering (TS) system for measuring electron temperature (*Te*) and density (*ne*) at the edge region of a plasma. In the vicinity of the plasma edge, we suppose to set an optical base of, say, 5 cm x 5 cm area. On the base, there are placed two lenses and fiber connectors. A lens (*f*~50mm) forms a slender laser beam with a focal point inside the plasma where is supposed to be the region of interest. The other lens focuses the backwardly scattered light onto the ends of optical fibers. The fibers in vacuum, used for laser and scattered light transmission, are connected to the fibers placed in air via vacuum-tight fiber-connectors attached to at an ICF34 vacuum flange. Since the optical fibers connected between the optical base and the fiber-connector are flexible, the optical base can be moved freely if an appropriate translator-actuator is equipped. Thus this system enables one to perform a scan-measurement on *Te* and *ne* during a plasma discharge. Although an optical fiber of a sub-mm diameter can transmit the average power as high as 30 W or more, the peak power is limited by the dielectric damage on the fiber below some MW/square-mm. So the fiber-based Thomson scattering is not suitable for the usually adopted several ns short-pulse operation which enables TS in the presence of an intense background plasma light. Hence, instead of short pulse method, we adopt the modulation method. A laser light from a fiber laser is on-off modulated with kHz frequency, and the scattered light, which is presumably deeply buried in plasma light, is detected by the phase sensitive method. The output (X) of photo-detector illuminated by the spectrum-analyzed scattered light is multiplied by the modulation reference signal (Y) with adjustable phase relay (ϕ) and integrated with a time constant τ. Thus obtained output Z is composed of scattered signal plus wideband noise. While the size of the scattered signal is independent of τ, the noise is inversely proportional to the square root of τ. Thus there is a trade off between the S/N and the time constant of the measurement (τ). With a 20 W laser light, it is roughly estimated that *Te* and *ne* could be measured with time constant τ =0.1s down to ne~$3*10^{12}$ cm^{-3}. For protection of the optical base together with its attachments against harsh plasma sputtering, the optical base is housed in a water-cooled box with a shutter when it is not in use and is protruded only when it is in use.